PDV for Measurement of Dynamic Strength on Transparent Materials Using Bar Impact

John Tolman, Stephan Bless, Scott Levinson
Institute for Advanced Technology
john_tolman@iat.utexas.edu

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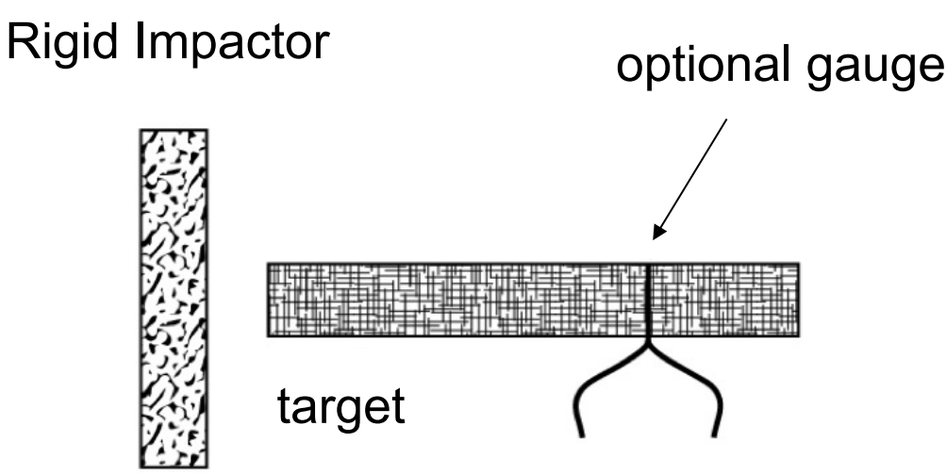
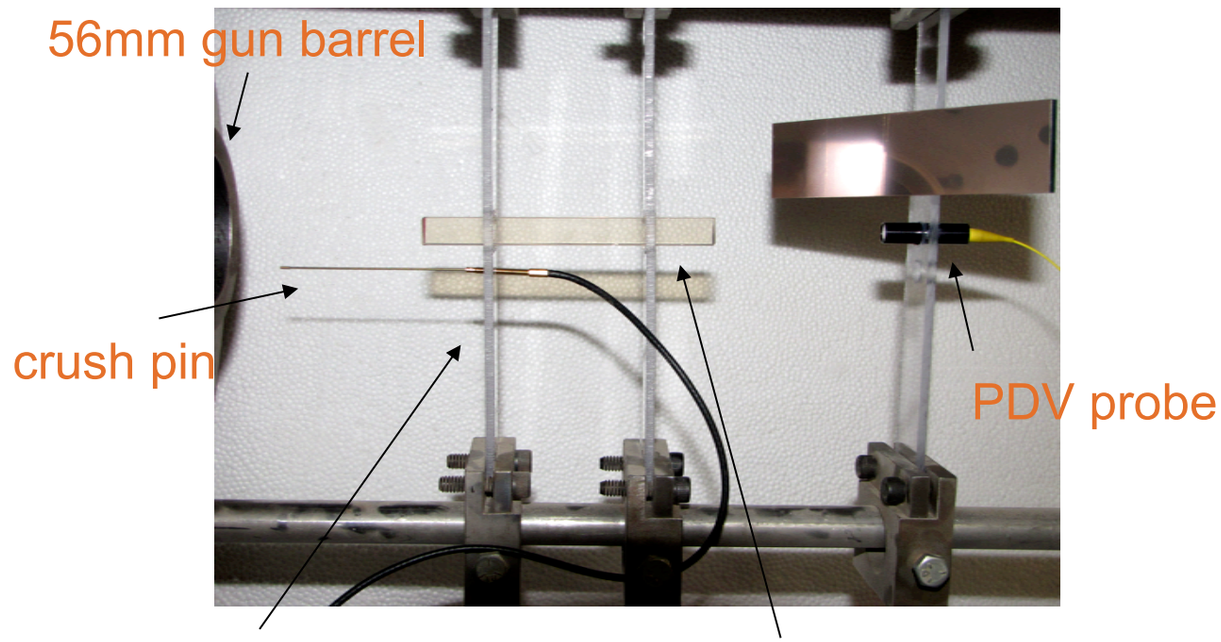
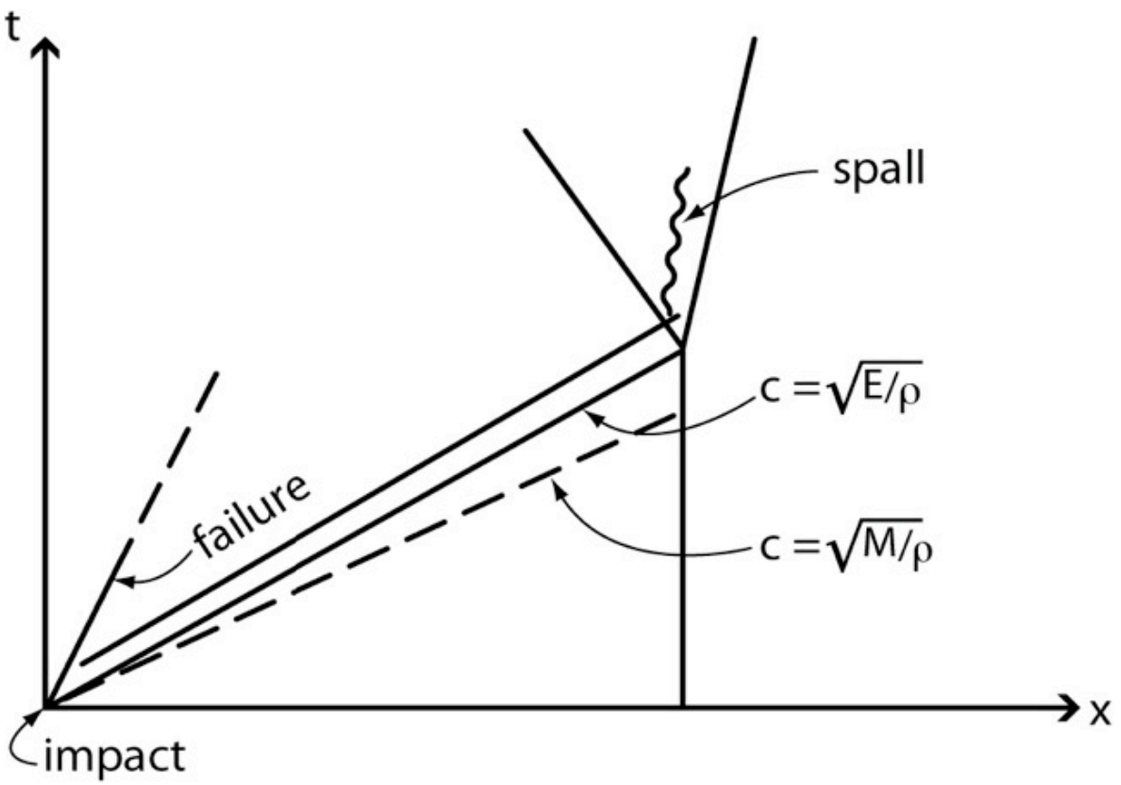
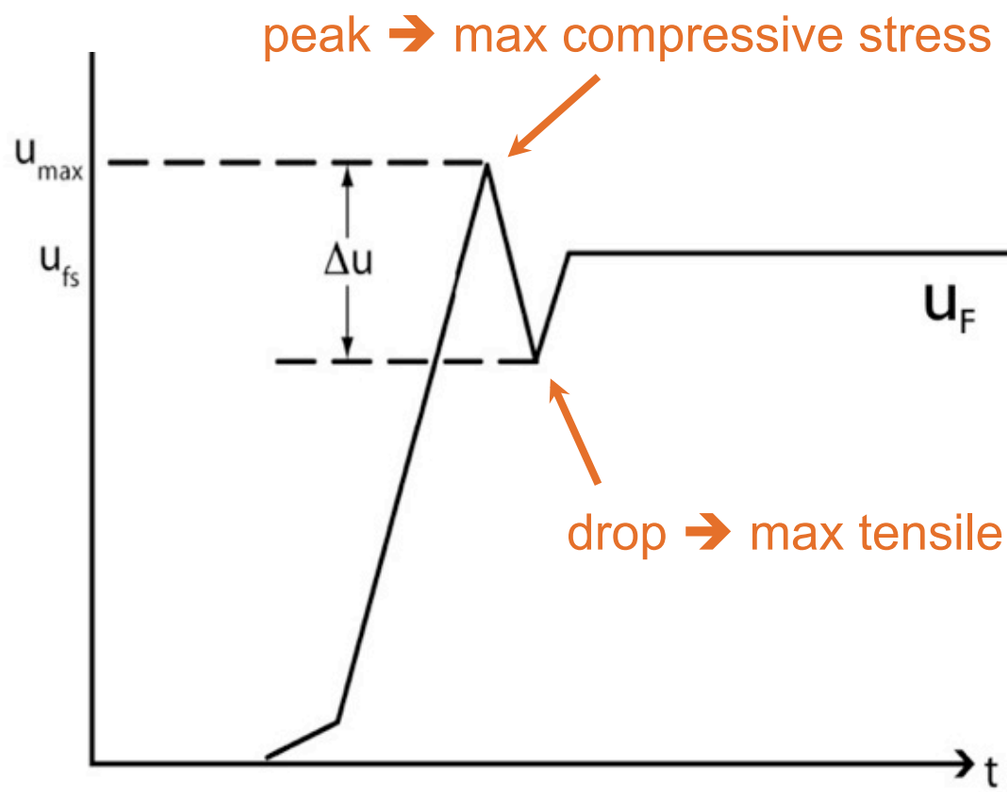
Advantages of bar impact method

- Larger Specimens
- Less Scatter
- Easy to photograph phenomena
- Measures unconfined compressive & tensile strength









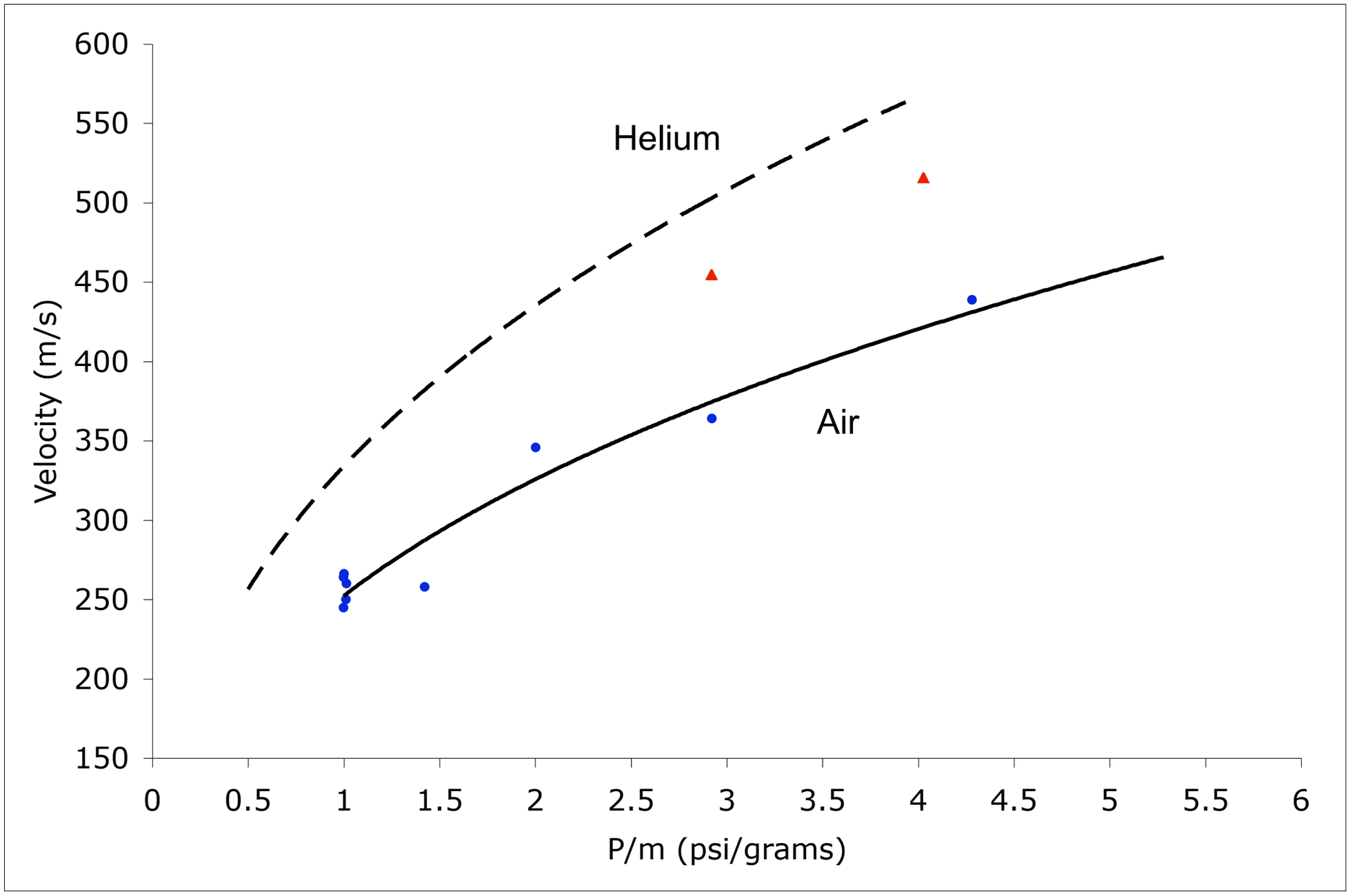
For ductile materials, a “square wave” is generated whose amplitude = yield stress. For brittle materials, failure at impact surface produces a stress pulse. Particle surface velocity doubles at free surface.

$$\sigma = \rho \cdot u_{FS} \cdot c$$

- Previous work on glass bars by Brar, Bless, Zienert, Murray et al, Wilmont.
- AlON bars observed by Cazamias.
- Strength of alumina bars : Coscuella, Bless, Beno and Bless, Simha, Galvez, Beno, Chhabildas, Najar
- Other studies of brittle bars by Zlatin, Glen & Janach, Forquin et al.

What's new here: FS measurements (without embedded gauges) on SLG & GC with time-resolved optical technique.

Borosilicate glass (12.7 mm round x 150 mm long)	2.2 g/cm^3	E = 62 GPa
Corning glass ceramic (25% nanocrystalline spinel) (10 mm square x 100 mm long)	2.8 g/cm^3	E = 93 GPa



Helium curve for 50 mm barrel (N K Bourne 2003)

Graded density impactor

- Nguyen, LLNL

Retro-reflecting tape

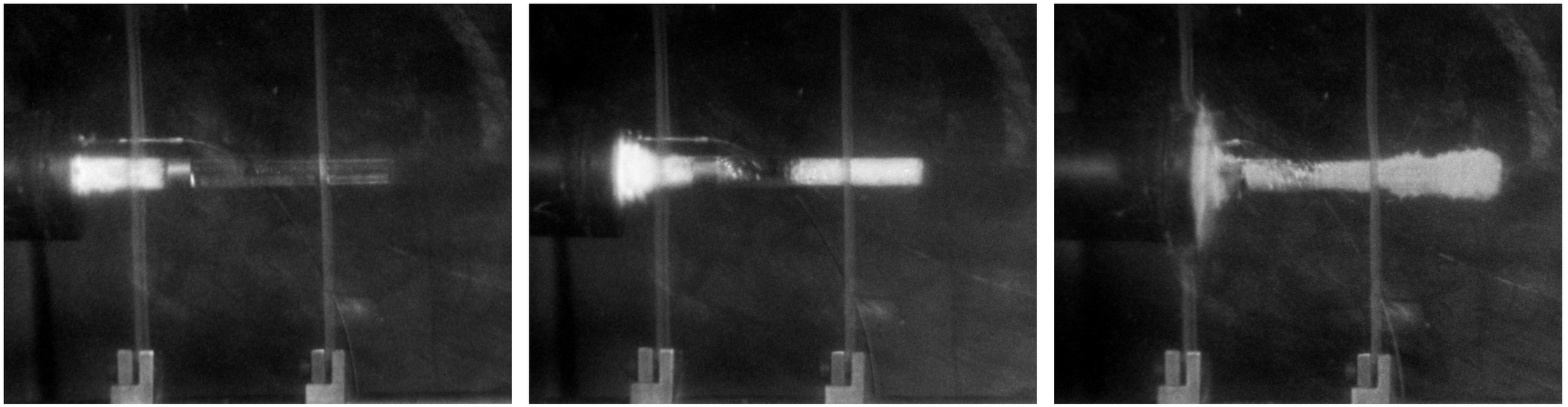
Polished target rear surface

Impact Velocity

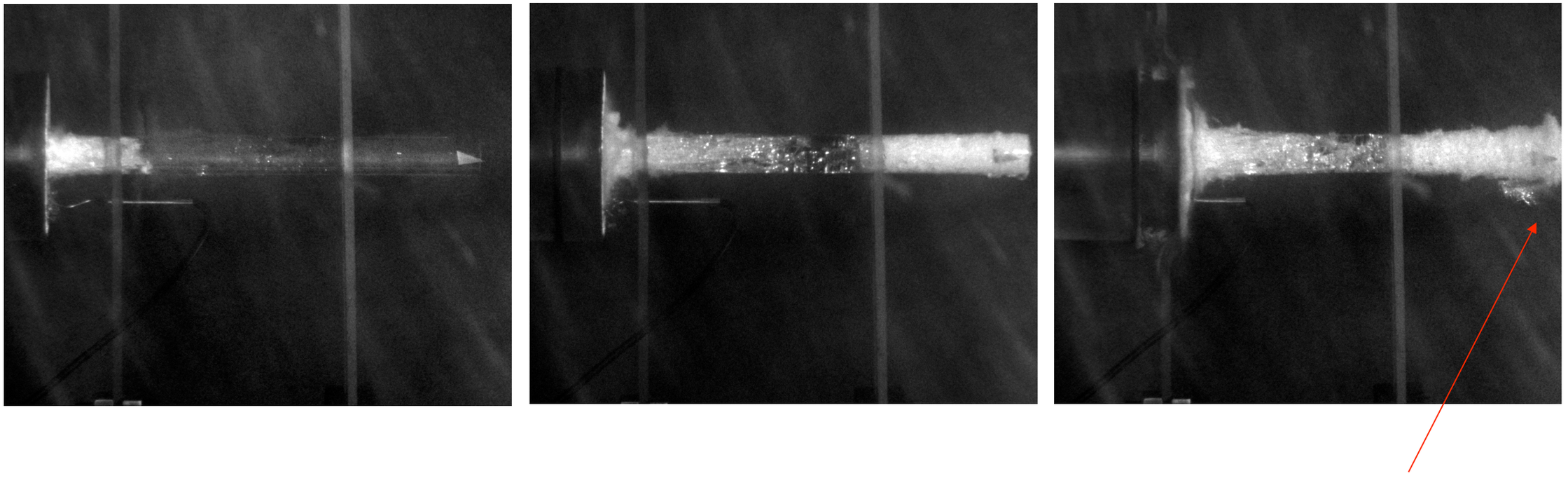
High-speed photography measurements of free surface velocity

velocity

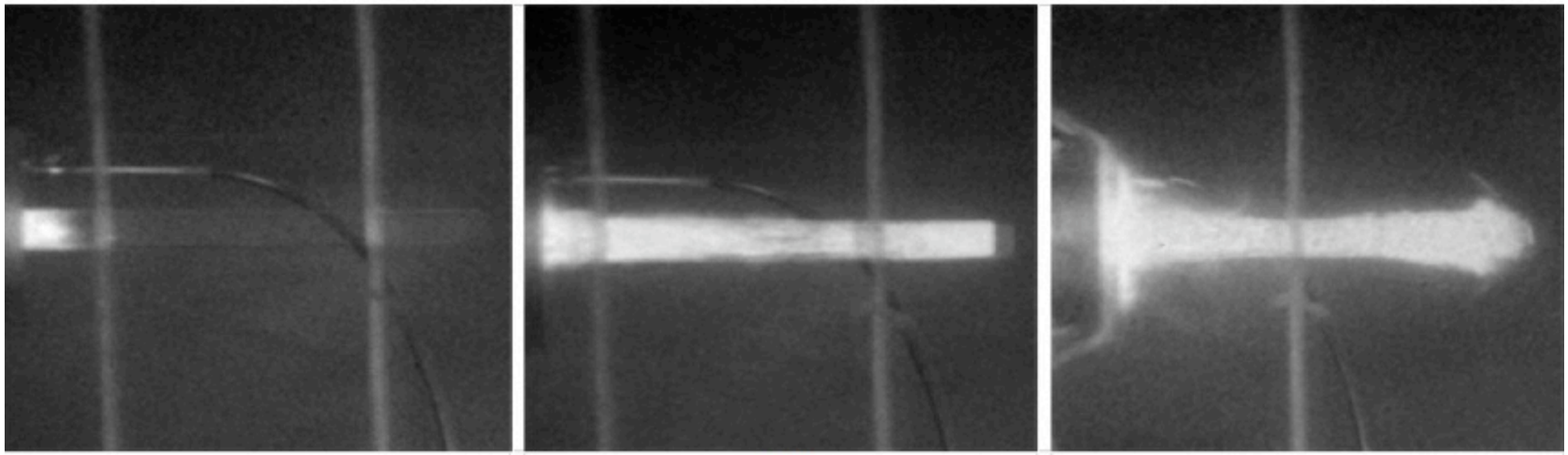
A) Shot # A1003



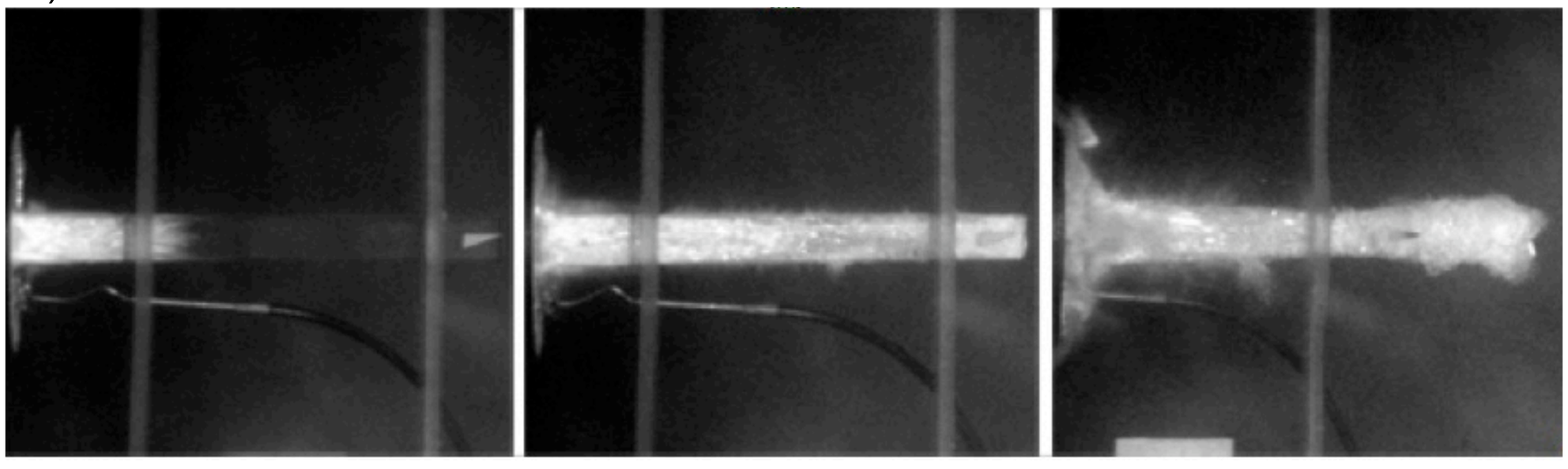
B) Shot # A1008



A) Shot # A1004



B) Shot # A1007



Heterodyne system

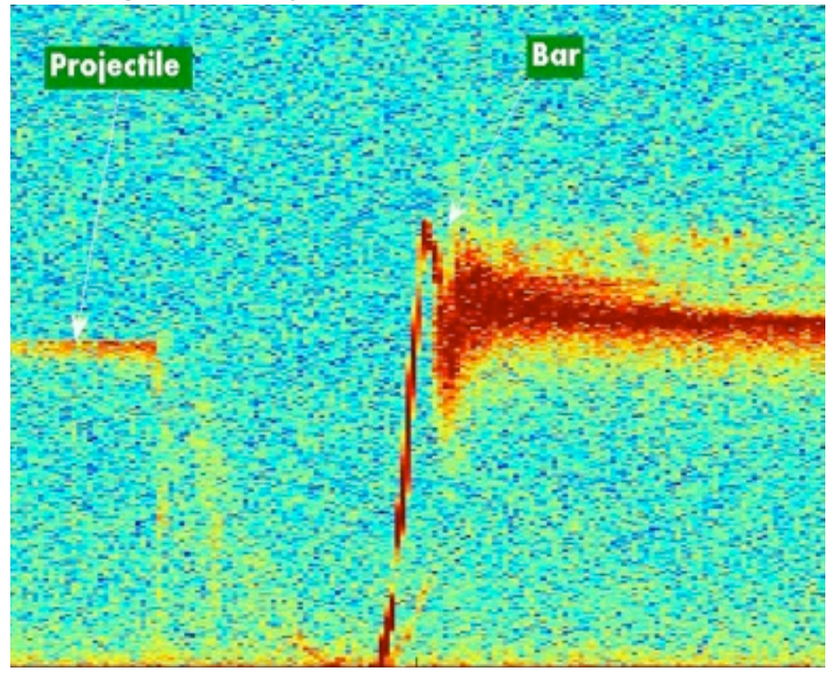
- Incident light is beat against reflected light

  Frequency shift is $2u_{fs}\lambda$

- Spectral analysis corresponds to velocity distribution

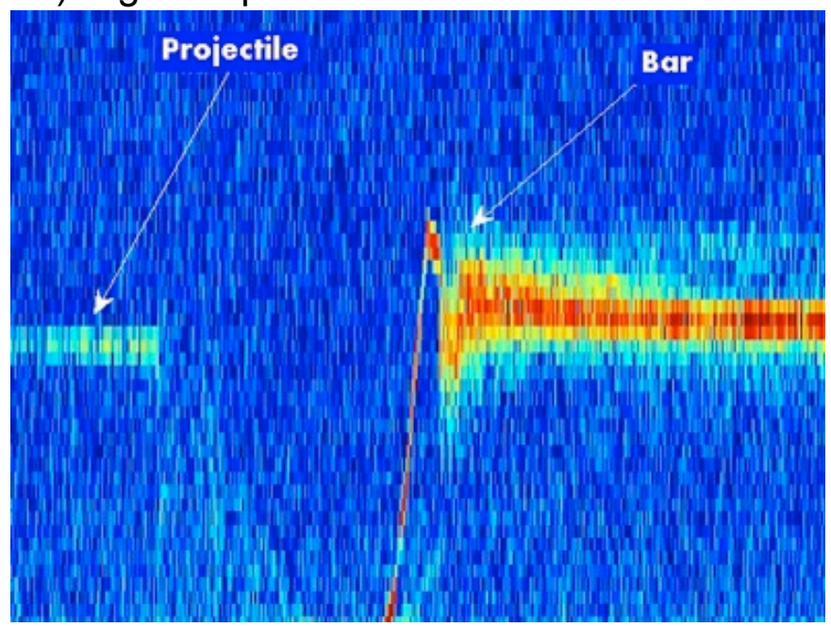
- Varying sample window can optimize temporal or velocity resolution

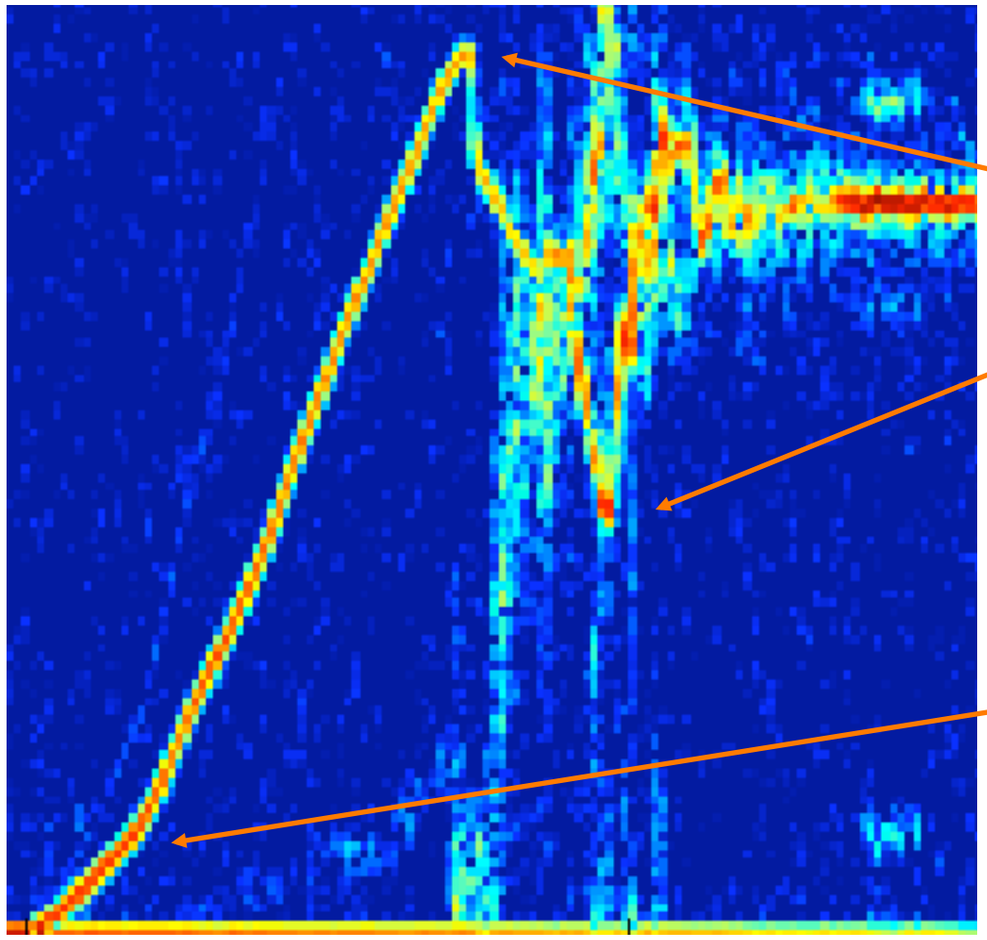
A) High velocity resolution



veloc

B) High temporal resolution





time

Peak stress = 2.2 Gpa

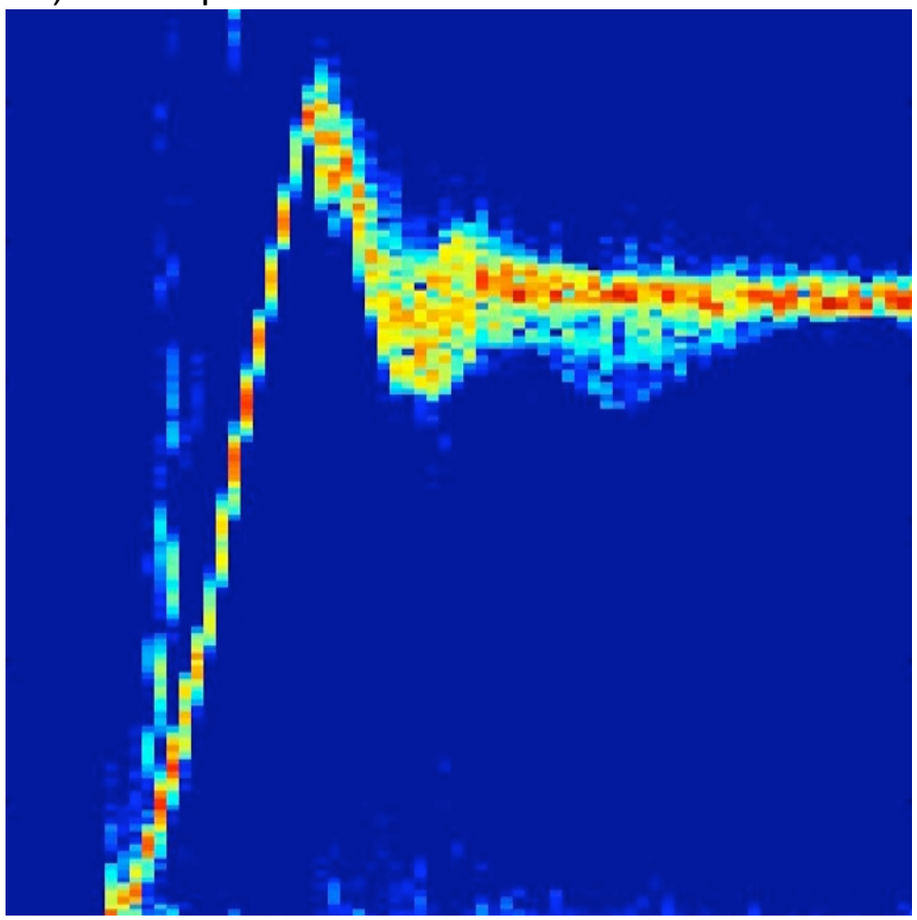
Spall pull back (?) = 187 m/s

Spall stress = 1.1 Gpa

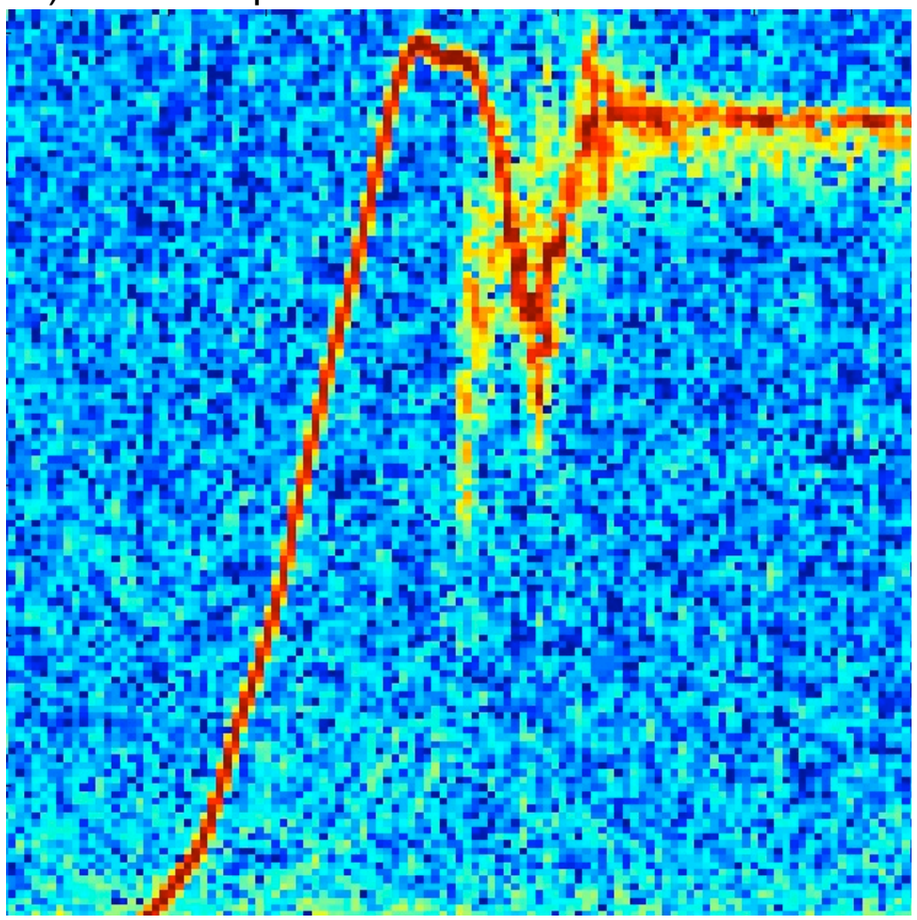
Final velocity = 307 m/s

Break between 1-D strain and 1-D stress waves

A) With tape



B) Without tape

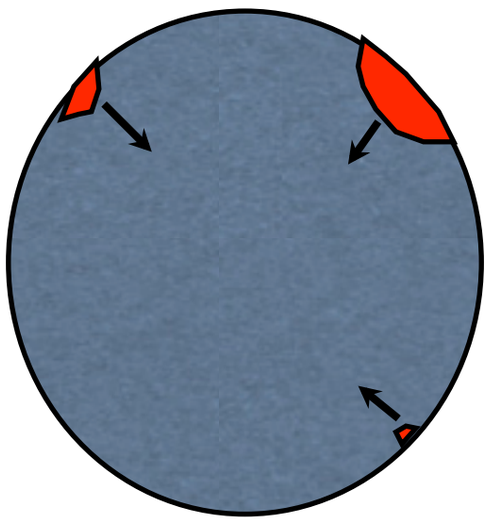


time

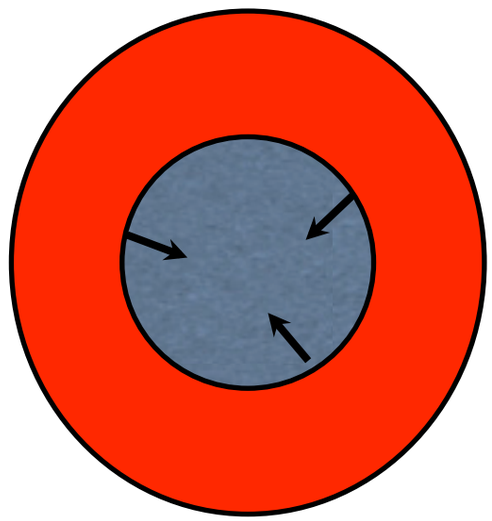
- Allows for external probes, decreases cost
- Smears out two wave arrivals
- Possible loss of peak and spall signal

Tensile failure in glass and GC is due to a failure wave that originates on the circumference.

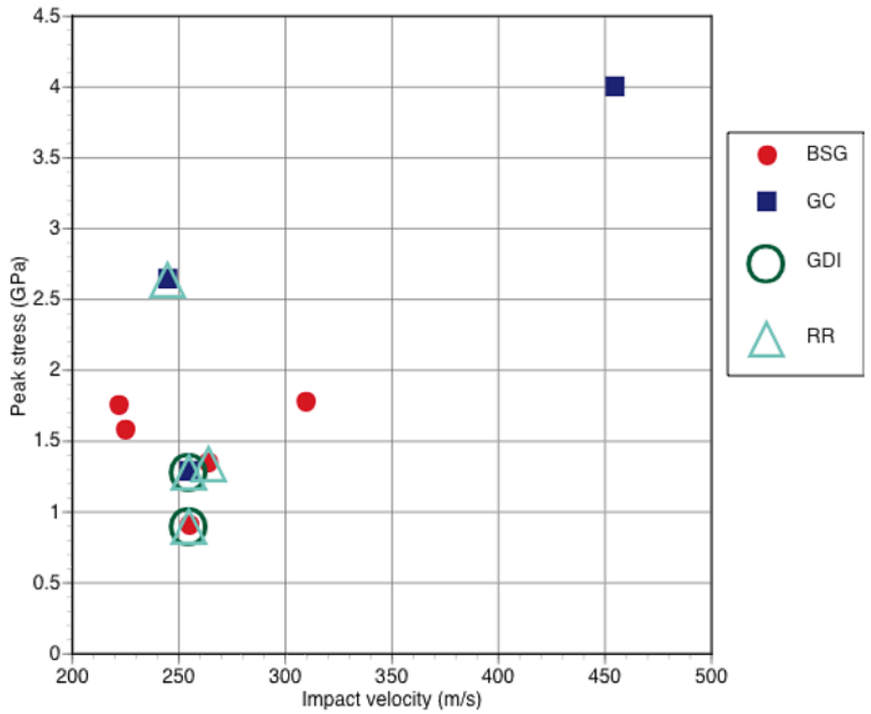
- Compressive failure of impact end
- Bar Separates when tensile wave reaches impact damage region (shown in simulations)

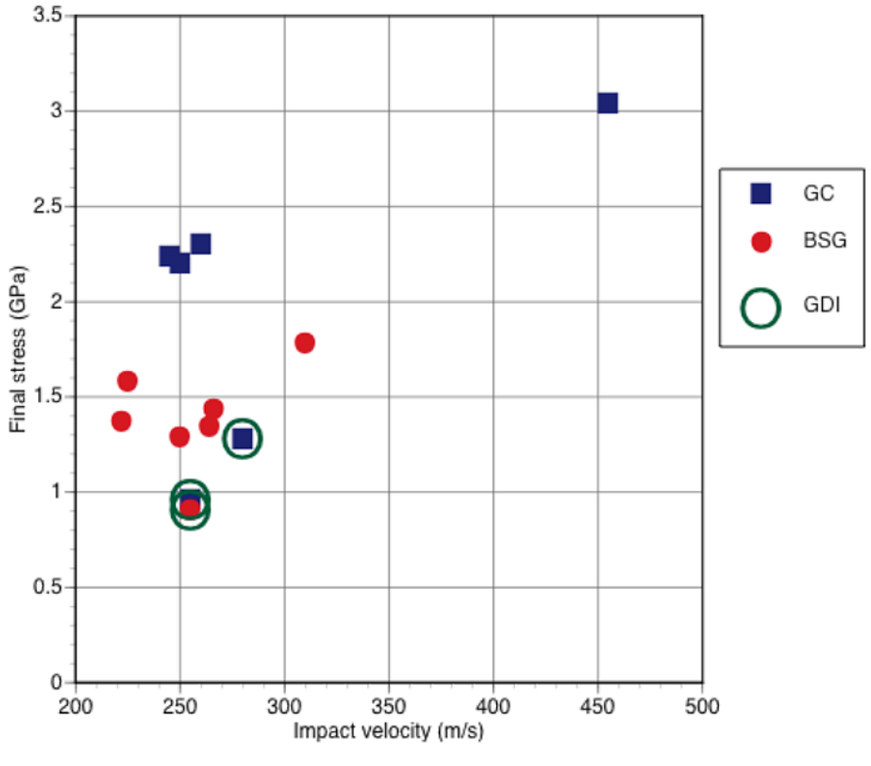


Stress goes tensile, flaws begin to grow

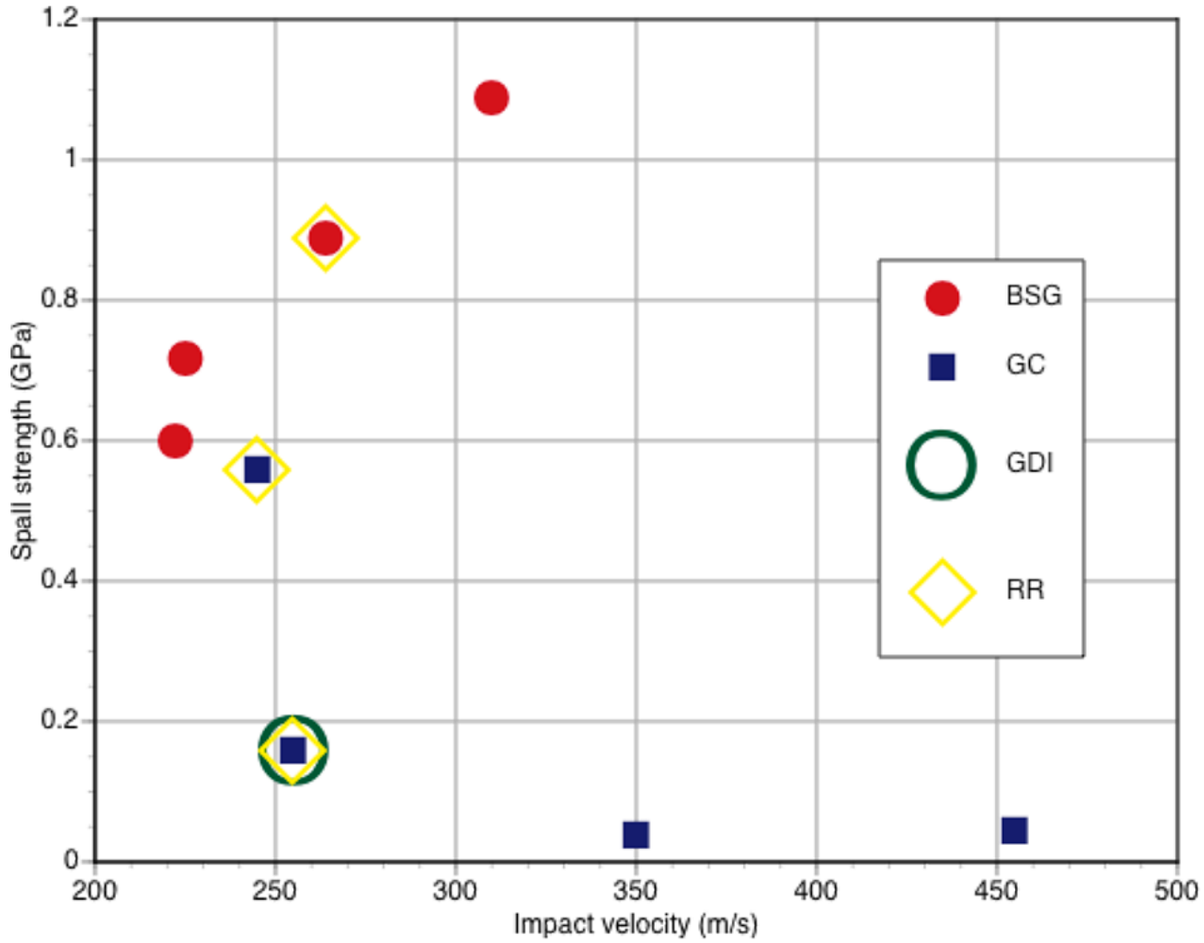


Surface flaws coalesce and propagate





- GDI reduced peak stress, lowers loading rate
- RR tape slightly clips peak stress
- GC >> stronger than BSG (photography, PDV agree)
- Loading rate effects in GC
- BSG may also be affected by loading rate



- Large uncertainty
  - Due to noisy and possibly multi-valued spall signal
- <u>BSG >> stronger than GC</u>
- All values lower than those from plate impact tests

1. Compressive stresses
   - GC > BSG
2. Tensile stresses
   - BSG > GC
3. Tests with larger loading rates for GC and BSG needed to verify if “limit” of compressive stresses has been found
4. Tensile strength is an extrinsic property?
   - Upcoming tests of BSG at larger scale